Abundances of other larval taxa were also variable among years in entrainment. Cyprinids ranged from 9.4 to 14.1 percent of entrained larvae (Tables C-18, C-20, and C-21). However, the greatest change in relative composition occurred among catastomid larvae, with spotted sucker larvae increasing from 5.9 and 6.4 percent of larval entrainment in 1983 and 1984, to 42.7 percent in 1985.

The total egg entrainment during February-July 1983 was calculated to be 9.2×10^6 eggs of which 4.3×10^6 eggs were entrained at 1G, 4.2×10^6 eggs at 3G, and 0.7×10^6 eggs at 5G (Table C-22). The most abundant species was American shad which represented 55.0 percent of the total eggs entrained (Table C-23). The other abundant groups were other eggs and striped bass eggs, representing 28.0 and 14.2 percent of the total egg entrainment, respectively.

The total fish egg entrainment during February-July 1984 was estimated to be 5.8×10^6 eggs, of which 2.7×10^6 eggs (46.6 percent) were entrained at the 1G pumphouse, 2.6×10^6 eggs (45.4 percent) at the 3G pumphouse and 0.5×10^6 eggs (8.0 percent) at the 5G pumphouse (Table C-22). The most abundant egg species was American shad, representing 50.3 percent of the total eggs entrained (Table C-23). The other abundant groups of eggs entrained were striped bass and other eggs, representing 30.6 and 15.2 percent of the total eggs entrained, respectively.

The total fish egg entrainment during February-July 1985 was estimated to be 15.1×10^6, of which 7.8×10^6 eggs (51.4 percent) were entrained at the
BB-3 1G pumphouse, 6.2×10^6 (41.4 percent) at the 3G pumphouse, 1.1×10^6 eggs
BD-5 (7.3 percent) at the 5G pumphouse (Table C-22). American shad eggs were most abundant in entrainment and represented 46.7 percent of the total eggs entrained (Table C-23). The other abundant groups of eggs entrained were striped bass and other eggs, representing 26.2 percent and 24.8 percent of the total entrained, respectively.

Total fish egg entrainment varied considerably among the years for which data are available. Average total entrainment from 1983-85 was 10.0×10^6 eggs at the three SRP intakes (Table C-22). However, egg entrainment varied almost threefold during those years from 5.8×10^6 in 1984 to 15.1×10^6 in 1985. The highest estimated egg entrainment occurred in 1982 (18.1×10^6), while estimated entrainment in 1977 (6.9×10^6) was near the low end of the range of values.

The proportions of total eggs entrained at each of the three intakes remained relatively constant from year to year. Highest egg entrainment occurred at the 1G intake during all years except 1977 when entrainment was highest at the 3G intake (Table C-22). The 1G intake averaged 49.1 percent of the total eggs entrained from 1983 to 1985. The 3G intake averaged 43.3 percent of total egg entrainment from 1983 to 1985, while the 5G intake averaged 7.6 percent of egg entrainment during this period.

American shad eggs dominated entrainment collections from 1983 to 1985 and the percentage of total egg entrainment attributable to this species was relatively constant (Table C-23). American shad eggs averaged 50.0 percent of egg entrainment and ranged from 46.7 percent (1985) to 55.0 percent (1983) of all eggs entrained. The number of American shad eggs entrained annually varied

Table C-22. Estimated Egg Entrainment at SRP Intakes[a]

		1G	3G	5G	Total
1977[b]	Number ($x10^6$)	2.4	4.0	0.5	6.9
	Percent	34.8	58.0	7.2	
1982[c]	Number ($x10^6$)	8.7	8.2	1.2	18.1
	Percent	48.3	45.1	6.6	
1983[d]	Number ($x10^6$)	4.3	4.2	0.7	9.2
	Percent	46.7	45.7	7.6	
1984[e]	Number ($x10^6$)	2.7	2.6	0.5	5.8
	Percent	46.6	44.8	8.6	
1985[f]	Number ($x10^6$)	7.8	6.2	1.1	15.1
	Percent	51.1	41.1	7.3	
Average number ($x10^6$)		4.9	4.3	0.8	10.0
(1983-85) percent		48.3	43.8	7.8	

a. Source: DOE, 1987.
b. April-June, McFarlane et al. (1978).
c. March-August, ECS (1983).
d. February-July, Paller et al. (1984).
e. February-July, Paller et al. (1985).
f. February-July, Paller et al. (1986).

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substantially, however, as total egg entrainment varied. The highest number of American shad eggs entrained was 7.1×10^6 in 1985. However, this species represented only 46.7 percent of total egg entrainment that year.

Striped bass eggs were less than half as abundant as American shad eggs in entrainment, averaging 23.4 percent (2.4×10^6 eggs/year) from 1983 to 1985 (Table C-23). However, striped bass eggs varied widely among years both as a percentage of total egg entrainment (14.2 - 30.6 percent) and as numbers of eggs entrained annually (1.3×10^6 - 4.0×10^6 eggs/year). Eggs of blueback herring, Dorosoma spp. (gizzard and/or threadfin shad) and percids were relatively minor components in entrainment. The undifferentiated component of other eggs represented a substantial component of egg entrainment, but likely included a wide variety of taxa, few of which represented substantial individual contributions to total egg entrainment.

Ichthyoplankton Withdrawal - The percentage of ichthyoplankton withdrawn from the Savannah River is determined by dividing the number of fish eggs and larvae entrained by the number of eggs and larvae transported past the intake canals in the Savannah River. The number of ichthyoplankton entrained at each intake is derived by summing the numbers of eggs and larvae that were entrained during each year (Table C-24). The number of ichthyoplankton that

Table C-23. Estimated Entrainment and Taxonomic Composition of Fish Eggs at SRP Intakes, 1983-85[a]

Taxa		1983[b]	1984[c]	1985[d]	Average
American shad	Number (x10^6)	5.07	2.91	7.06	5.01
	Percent	55.0	50.3	46.7	50.0
Blueback herring	Number (x10^6)	0.09	0.07	0.14	0.10
	Percent	1.0	1.2	0.9	1.0
<u>Dorosoma</u> spp.	Number (x10^6)	–[e]	0.13	0.21	–[f]
	Percent	–[e]	2.2	1.4	–[f]
Striped bass	Number (x10^6)	1.31	1.77	3.96	2.35
	Percent	14.2	30.6	26.2	23.4
Unident. percids	Number (x10^6)	0.16	0.02	–[e]	–[f]
	Percent	1.7	0.3	–[e]	–[f]
Other eggs	Number (x10^6)	2.58	0.88	3.74	2.4[g]
	Percent	28.0	15.2	24.8	25.6[g]
Total number (x10^6)		9.21	5.78	15.11	10.03

BB-3
BD-5
a. Source: DOE, 1987.
b. Paller et al. (1984).
c. Paller et al. (1985).
d. Paller et al. (1986).
e. Not provided in source document.
f. Not calculated because of partial data.
g. Includes <u>Dorosoma</u> spp. and unident. percids.

were vulnerable to entrainment was estimated by multiplying ichthyoplankton densities in the river near the canals times the river discharge on that date. Ichthyoplankton densities at RM 157.3 were used for entrainment at the 1G intake, and densities at RM 155.4 were used for estimates at the 3G and 5G intakes. Annual ichthyoplankton transport was derived by extrapolating the weekly measurements through the sampling season (February to July).

The total number of ichthyoplankton entrained was consistently highest at the 3G intake and ranged from 11.4 x 10^6 ichthyoplankton in 1984 to 17.4 x 10^6 in 1983 (Table C-24). Entrainment at the 1G intake was slightly less than at 3G, while a much smaller number of ichthyoplankton was entrained at the 5G intake.

Total number of ichthyoplankton entrained was highest in 1983, with substantially lower numbers of eggs and larvae entrained in 1984 and 1985 (Table C-24). Total numbers of ichthyoplankton entrained were similar in 1984 and 1985.

Table C-24. Percentage of Savannah River Ichthyoplankton Entrained at SRP Intakes, 1983-85[a]

		1983[b]	1984[c]	1985[d]
Number entrained ($x10^6$)	1G	17.2	10.4	11.6
	3G	17.4	11.4	12.6
	5G	2.5	1.5	1.8
	Total	37.1	23.3	26.0
Number transported in River ($x10^6$)	RM 157.3	388	282	212
	RM 155.4	405	216	133
Percent entrained	1G	4.4	3.7	5.5
	3G	4.3	5.3	9.5
	5G	0.6	0.7	1.4
	Total[e]	9.6	8.3	12.3
Percent river withdrawn[f]		7.7	7.0	12.2

a. Source: DOE, 1987.
b. Paller et al. (1984).
c. Paller et al. (1985).
d. Paller et al. (1986). BB-3
e. Based on transport at RM 157.3. BD-5
f. All intakes combined, February-July.

Estimates of ichthyoplankton transport varied among years and between transects at which transport was calculated (Table C-24). Highest ichthyoplankton transport occurred during 1983 when densities (Table C-15a) and river discharge (Table C-25) were both relatively high. Ichthyoplankton transport past the SRP intakes was substantially lower in 1984 and 1985. In 1984 ichthyoplankton densities were relatively low (Table C-15b), while river discharge was slightly below that observed in 1983 (Table C-25). Ichthyoplankton densities in 1985 (Table C-15c) were comparable to densities observed in 1983, but river discharge was extremely low as a result of low winter rainfall and relatively low releases of water from Clarks Hill Reservoir.

The combined effects of changes in ichthyoplankton density and river water discharge among years resulted in differences in estimates of the percentages of ichthyoplankton entrained from the river each year (Table C-24). The percentage of ichthyoplankton entrained at all intakes was lowest in 1984 (8.3 percent) and only slightly higher in 1983 (9.6 percent). The highest percentage of river ichthyoplankton entrained was in 1985 (12.3 percent) when Savannah River discharge was low during the spawning season (Table C-25).

The primary factor that appears to influence the percentage of river ichthyoplankton entrained in the SRP intakes is the percentage of river water withdrawn (Table C-24). Although the volume of river water withdrawn by the SRP remained relatively constant during the spawning season among the three

Table C-25. Monthly Average[a] Savannah River Discharge (m^3/sec) at the Jackson Gauge, Water Years[b], 1972-85[c]

	1972-82						
	Average	Maximum	Minimum	1983 Average	1984 Average	1985 Average[d]	1983-85 Average
October	208.7	247.7	143.6	190.1	173.8	184.1	182.7
November	249.7	410.2	129.2	170.4	164.2	182.7	172.4
December	285.7	395.7	162.4	247.9	258.5	172.3	226.3
January	359.1	461.6	190.8	418.6	366.8	183.6	323.0
February	412.6	533.6	221.9	493.4	403.2	375.5	424.0
March	332.9	529.2	195.4	513.3	469.3	211.8	398.1
BB-3 BD-5 April	338.3	561.0	188.1	503.3	412.3	177.9	364.5
May	300.5	394.5	160.9	257.0	396.5	157.7	270.4
June	305.7	560.8	190.0	297.3	250.9	151.5	266.6
July	231.7	391.5	154.8	196.9	234.1	164.8	198.8
August	204.5	241.5	161.1	187.7	343.8	162.1	231.2
September	199.5	232.0	241.5	189.8	216.8	155.4	187.3

a. Average discharge underestimated during high flow, maximum discharge reliably measured is approximately 625 m^3/sec, which was used in calculations when discharge exceeded that value.
b. Water Year is October-September, e.g., Water Year 1985 is October 1984-September 1985.
c. Source: DOE, 1987.
d. Source: USGS, 1986.

years (Table C-26), river discharge varied substantially and the percentage of river water withdrawn during the spawning season was higher in 1985 than in 1983 or 1984.

Impingement - Studies to measure and evaluate the loss of fish trapped on the traveling intake screens began in 1977 (McFarlane, Frietsche, and Miracle, 1978). They resumed in March 1982 and continued through 1985 (ECS, 1983; Paller et al., 1984; Paller and Osteen, 1985; Paller and Saul, 1986) as part
BB-3 of the expanded ongoing Savannah River aquatic ecology program. Results of
BD-5 these investigations indicate that several factors, including the number of pumps in operation, the volume of water pumped, the river water level, the

Table C-26. Monthly Volume and Percent of Savannah River Water Withdrawn at the 1G and 3G Intakes at the SRP, 1983-85[a]

		1983	1984	1985
January	Volume (m^3/sec)	23.7	25.3	23.0
	Percent of River[b]	5.8	5.6	12.9
February	Volume (m^3/sec)	22.5	15.2	22.8
	Percent of River	4.6	4.1	6.7
March	Volume (m^3/sec)	22.6	18.0	21.6
	Percent of River	4.4	4.4	10.5
April	Volume (m^3/sec)	22.8	23.7	21.8
	Percent of River	4.1	6.3	12.4
May	Volume (m^3/sec)	22.8	23.6	22.8
	Percent of River	9.3	6.4	14.6
June	Volume (m^3/sec)	16.9	22.0	18.7
	Percent of River	6.4	9.2	12.6
July	Volume (m^3/sec)	19.5	22.2	15.7
	Percent of River	10.2	9.8	9.5
August	Volume (m^3/sec)	23.4	23.1	15.3
	Percent of River	12.7	7.8	9.5
September	Volume (m^3/sec)	22.6	23.8	16.4
	Percent of River	12.1	11.3	10.7
October	Volume (m^3/sec)	23.1	18.8	19.9
	Percent of River	13.5	10.5	–[c]
November	Volume (m^3/sec)	22.9	14.4	21.3
	Percent of River	14.4	7.9	--
December	Volume (m^3/sec)	23.6	22.0	18.2
	Percent of River	9.8	13.1	--

a. Source: DOE, 1987.
b. Percentage overestimated during months of high river discharge.
c. River discharge volume not available.

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water temperature, and the density and species of fish in the intake canal, influence the impingement rate to some degree.

Impingement data were summarized from the reports prepared on these investigations (DOE, 1987). Although impingement samples were collected from March 1982 to September 1985, the samples used in this evaluation are primarily from September 1982 through September 1985 because methodologies were consistent during this interval. Additional unpublished data from October to December 1985 were included as appropriate.

In a preliminary biological measurement program, collections of impinged fishes on the traveling screens at the 1G, 3G, and 5G intakes were made biweekly between April and August 1982. Between September 1982 and August 1985 collections were made on approximately 100 randomly selected sampling dates yearly. The data collected after August 1982 more accurately represent impingement over an annual cycle because the frequency of collection was higher and more consistent.

Impingement at 1G and 3G intakes varied substantially each year. The maximum annual impingement collections occurred at the 1G intake in 1983 (1462 fish, Table C-27). By extrapolating the estimated daily impingement for 1983, it is estimated that 5336 fish were impinged at the 1G intake per year. The highest annual impingement collections at the 3G (1150 fish) and 5G (1282 fish) intakes also occurred in 1983 with an estimated annual impingement of 4198 and 4679 fish per year, respectively. Although the sampling effort remained constant from 1983 through 1985, both the actual (measured) impingement and the estimated annual impingement declined at the 1G and 3G intakes. The minimum estimated annual impingement occurred in 1985 at the 1G (1670 fish) and 3G (1316 fish) intakes; minimum annual impingement occurred in 1984 at the 5G intake (213 fish). Average estimated annual impingement for the three year period was 3124 fish (8.56 fish/day) at the 1G intake, 2761 fish (7.56 fish/day) at the 3G intake, and 1718 fish (4.70 fish/day) at the 5G intake.

BB-3 Impingement at the SRP intakes is strongly seasonal. Approximately 60 percent
BD-5 of the fish impingement at 1G and 3G during 1983-1985 occurred from March through May (63.3 percent at 1G; 58.4 percent at 3G: Figure C-7). Almost 93 percent of impingement at the 5G intake occurred during these months. The largest number of impinged fish were collected in May, when approximately one-third of the annual impingement occurred over the three-year period at 1G and 3G. However, 65 percent of annual impingement at the 5G intake occurred during April. No month other than March, April, and May exhibited greater than ten percent of the annual average impingement at the 1G intake. However, substantial impingement occurred during January (11.1 percent) and December (12.3 percent) at the 3G intake. Impingement was low during the late summer and fall months at all intakes.

At least 62 species of fish, representing 17 families, were impinged at SRP intakes from March 1982 to December 1985 (Tables C-28 and C-29). Twenty species were collected in such abundance that the species collection represented more than one percent of the total collections between September 1982 and September 1985 (Table C-28). Blue-spotted sunfish (23.29 percent) and threadfin shad (11.39 percent) were the most abundant species in impingement samples at all intakes during this three-year period. Among the remaining species only gizzard shad (6.31), redbreast sunfish (5.49 percent), and warmouth (5.30 percent) exceeded five percent of the total collections. Thus, overall impingement losses from the Savannah River were fish identified as forage species with little commercial or recreational value.

However, species specific impingement varied substantially among the three intakes and among years. For the period from September 1982 through August 1983, blue-spotted sunfish dominated impingement collections at the 1G and 5G

Table C-27. Total Annual Impingement at 1G, 3G and 5G Intakes[a]

Year		Intake 1G	Intake 3G	Intake 5G
1982	Total fish collected	73	284	84
	Number of days sampled	43	43	43
	Average impingement/day	1.70	6.60	1.95
	Estimated annual impingement	619.7	2410.7	713.0
1983	Total fish collected	1462	1150	1282
	Number of days sampled	100	100	100
	Average impingement/day	14.62	11.50	12.82
	Estimated annual impingement	5336.3	4197.5	4679.3
1984	Total fish collected	655	766	59
	Number of days sampled	101	101	101
	Average impingement/day	6.48	7.58	0.58
	Estimated annual impingement	2367.0	2768.2	213.2
1985[b]	Total fish collected	430	339	67
	Number of days sampled	94	94	94
	Average impingement/day	4.57	3.61	0.71
	Estimated annual impingement	1669.7	1316.3	260.2
1983-85[c] average	Total fish collected	849.0	751.7	469.3
	Number of days sampled	98.3	98.3	98.3
	Average impingement/day	8.56	7.56	4.70
	Estimated annual impingement	3124.3	2760.7	1717.6

a. Source: DOE, 1987.
b. Includes unpublished data from October-December 1985.
c. Only 1983-85 data were used for these calculations because sampling was limited in 1982. BB-3 BD-5

intakes while threadfin shad dominated collections at 3G (Figure C-8a). From September 1983 through August 1984 threadfin shad dominated collections at the 1G intake and blue-spotted sunfish were a relatively minor component of the 1G collections (Figure C-8b). Blue-spotted sunfish dominated collections at the 3G and 5G intakes during this latter period. From September 1984 through September 1985 impingement collections were relatively low at all intakes and gizzard shad were most abundant in 1G intake collections, threadfin shad dominated collections at 3G, and American shad were most abundant at the 5G intake (Figure C-8c). Centrarchids did not dominate the collections at any of the three intakes during this last period.

Table C-28. Number and Percentages of Fish Species Representing Greater Than One Percent of Impingement Collections at the 1G, 3G and 5G Intakes, September 1982-September 1985[a]

Species	Number	Percent
Bluespotted sunfish	1465	23.30
Threadfin shad	716	11.39
Gizzard shad	397	6.31
Redbreast sunfish	345	5.49
Warmouth	333	5.30
Flier	313	4.98
Hogchoker	252	4.01
Spotted sunfish	218	3.47
Bluegill	179	2.85
Black crappie	171	2.72
Bowfin	162	2.58
Blueback herring	141	2.24
Spottail shiner	122	1.94
Pirate perch	119	1.89
Dollar sunfish	112	1.78
Pumpkinseed	85	1.35
White catfish	82	1.30
Redfin pickerel	77	1.22
Flat bullhead	70	1.11
Mud sunfish	69	1.10
Total of minor species	860	13.68
Total	6288	100.00

a. Source: DOE, 1987.

The impingement of fish at SRP intakes appears to be strongly selective and relative to the abundance of fish in the intake canals. Quarterly electrofishing of the intake canals revealed that the fish community in the canals is strongly dominated by centrarchids (Figures C-8a, C-8b, and C-8c). During the sampling period September 1982 through September 1985, the electrofishing collections were dominated by a mixture of bluegill, redbreast, and dollar sunfish at all intake areas. Chain pickerel were collected routinely, while yellow perch, suckers, largemouth bass, and spotted sunfish appeared less routinely in collections, but occasionally in substantial numbers. The most notable exception to this pattern is the dominance of flat bullhead, white catfish, and channel catfish in collections near the 5G intake during September 1984 through September 1985. Generally, those species that were dominant in electrofishing collections were not abundant in impingement collections. BB-3 BD-5

The findings on the relative abundance of fish in the Savannah River near the SRP intakes and in the impingement collections were analyzed relative to the

Table C-29. Species of Fish Collected at the 1G, 3G, and 5G Intakes Representing Less Than One Percent of Total Collections, September 1982-September 1985[a]

	Hickory shad	Speckled madtom
	American shad	Margined madtom
	Chain pickerel	Redear sunfish
	Golden shiner	Blackbanded sunfish
	Pugnose minnow	Largemouth bass
	Ohoopee shiner	Banded sunfish
	Coastal shiner	White crappie
	Bannerfin shiner	Green sunfish
BB-3	Carp	Yellow perch
	Whitefin shiner	Blackbanded darter
	Eastern silvery minnow	Tesselated darter
	Spotted sucker	Swamp darter
	Creek chubsucker	Mudminnow
	Lake chubsucker	Eastern mudminnow
	Chubsucker	Atlantic sturgeon
	Silver redhorse	American eel
	Channel catfish	Unidentified killifish
	Snail bullhead	Mosquitofish
	Brown bullhead	Brook silverside
	Yellow bullhead	Striped bass
	Tadpole madtom	Atlantic needlefish

a. Source: DOE, 1987.

angler catches in freshwater sections of the Savannah River. Fish species caught by anglers in the Savannah River represent an extremely limited set of available species. Electrofishing collections made during 1980-1982
BB-3 throughout the freshwater sections of the lower Savannah River have indicated
BD-5 that the taxa caught by anglers represented only 33.1 percent of the numerical abundance collected in electrofishing. Similarly, those species that constitute 95.8 percent of the angler catch constitute only 27.8 percent of total impingement at the SRP intakes. The species caught by anglers represent 59.8 percent of the fish caught by electrofishing and 86.9 percent of hoop-net sampling from the Savannah River near the SRP intakes. However, Paller and Osteen (1985) noted that the electrofishing collections near SRP do not accurately reflect the abundance of minnows and other small species. The same caution undoubtedly applies to hoop-net collections because the hoop-nets used for the SRP collections had a maximum mesh size of 37 millimeters.

BB-3

Bream represent the largest component of the anglers' catch in the Savannah River. Although centrarchids were a substantial component of SRP impingement collections, the species impinged were not predominantly those caught by anglers (Figure C-9). Although redbreast sunfish are abundant in the creel (27.1 percent and in the river near the intakes (26.7 percent), they represented only 5.5 percent of impingement. Bluegill show much higher relative abundance in the anglers' catch than in the river (all methods) and impingement. Among the bream caught by anglers, only the spotted sunfish represents a higher relative abundance in impingement (3.5 percent) than in the creel (1.1 percent), but the species relative abundance in impingement is less than the relative abundance in electrofishing collections (5.2 percent).

Crappie, yellow perch, and largemouth bass all exhibit higher relative abundances in the creek (8.0 percent, 3.0 percent, and 3.2 percent, respectively) than in impingement (2.9 percent, 0.8 percent, and 0.5 percent, respectively, Figure C-9). All three species exhibit higher relative abundance in the river (by at least one collection method) than in impingement. Largemouth bass exhibits higher abundance in the river (by at least one collection method) than in impingement, and exhibits higher relative abundance in the river than in the creel. Chain pickerel is a minor component of the creel (0.9 percent) and has comparable abundance in impingement (0.7 percent).

Relative abundances of all taxa of catfish [bullhead spp. (2.1 percent), channel catfish (0.8 percent), and white catfish (1.3 percent)] taken in impingement samples were lower than relative abundances for those taxa in the creel (8.2 percent, 4.2 percent, and 2.1 percent, respectively, Figure C-9). However, the relative abundances of these taxa in hoop-net collections from the river were substantially higher than for either impingement or angler catches. The disparity between relative abundances of catfish taxa in electrofishing and hoop-net collections suggests that catfish are a substantial component of the Savannah River ichthyofauna, and that electrofishing provides a poor estimate of the abundance of these taxa. BB-3

American shad, striped bass and hybrid bass were minor components with all of the collection methods (angling, electrofishing, hoop-netting, impingement, Figure C-9). The abundance of the migratory American shad and striped bass in the Savannah River near SRP was undoubtedly underestimated during the quarterly sampling program. Nevertheless, the low frequency of these species in impingement collections (taken in approximately 100 collections throughout the year) is highly encouraging because it indicates that adults and juveniles of these species are minimally influenced by impingement mortality associated with SRP operations.

Status of Savannah River Fish Populations

The primary source documents containing the data used in this section are referenced in DOE (1987). TE

Relatively little is known about the current status of fishery stocks in the Savannah River and the overall levels of mortality sustained by individual species populations. The creel survey in DOE (1987) represents a significant addition to the knowledge of sports fishing pressure on individual species in freshwater and estuarine areas of the lower Savannah River. Concurrent sampling of the creel census areas using electrofishing and rotenone provided additional information on abundance and species composition of resident species. BB-3

American shad stocks appear to be healthy and productive in the Savannah River. Reports on commercial catches by Georgia shad fishermen in 1980 indicated that the Savannah River produced the greatest catches (in pounds of fish and income) in the state, representing 51 percent of Georgia shad landings in that year, while only 13 percent of Georgia's commercial shad fishermen operated in the river during that year. Thus, American shad stocks in the Savannah River may be less heavily exploited and relatively more abundant than stocks in other Georgia rivers. Additionally, researchers have reported on the development of a previously undocumented sport fishery for American shad in the vicinity of the New Savannah Bluff Lock and Dam, and have recommended that the magnitude of this fishery be evaluated.

Less is known about the status of striped bass in the Savannah River. Only recently has spawning upstream of tidally influenced regions of the river been documented (ECS, 1983, Paller et al., 1984, Paller et al., 1985, Paller et al., 1986). Nevertheless, it has been suggested that striped bass spawning occurs primarily in the tidally influenced portions of the river. It is not clear whether the current spawning of striped bass in upstream regions of the river represents a re-establishment of a spawning stock in this area, or is a result of the increased intensity of sampling efforts during 1982-1985 relative to prior sampling programs.

BB-3

Although relatively little is known concerning fish stocks, the quality of fish habitat in the river near the SRP has likely improved. The recent improvement of the sewage treatment facilities in Aiken County, South Carolina, have undoubtedly resulted in improvement of water quality in Horse Creek, which enters the Savannah River at RM 197.4. The continuing upgrading of sewage treatment facilities for the Augusta, Georgia, area will result in improved water quality in Butler Creek (RM 187.2) which enters the river near the New Savannah Bluff Lock and Dam. The river section from the New Savannah Bluff Lock and Dam to downstream of Spirit Creek (RM 182.2) has been identified as an area of degraded water quality.

Overall, there is currently no basis for concluding that fish stocks in the Savannah River are adversely affected by SRP operations. Although direct assessment of recent changes in fish stocks is currently not feasible, the losses of fish resulting from SRP operations are small and localized. Such small losses should not result in a significant risk to the abundance or persistence of fish stocks in the lower Savannah River.

Thermal Effects on Larval Fish

Studies of the thermal tolerance of early life stages of largemouth bass, bluegill, and channel catfish indicated that these species can tolerate higher (several degrees) temperature than the highest observed spawning temperature (Du Pont, 1985). The optimal temperatures for largemouth bass and channel catfish larvae were found to be 24°C and 28°C, respectively. The 24-hour median lethal temperature for largemouth bass larvae was found to range from 32°C to 36°C, while that for bluegill larvae was 36°C to 38°C. The incipient lethal temperature for channel catfish larvae was determined to be 33°C to 36°C. Studies on cold shock conducted on early life stages of largemouth bass and channel catfish indicated that neither species would be likely to suffer mortality if stream temperatures returned to ambient levels during the late spring spawning season.

TE

Fish kills from cold shock can be equally important in environments such as Four Mile Creek and Pen Branch that are thermally constant for long periods of time during extended reactor operation, and then cool rapidly when reactor operations stop (Du Pont, 1985).

Chlorination/Dechlorination Effects

Experimental studies were conducted to evaluate the potential effects of chlorination and dechlorination of K- and C-Reactor cooling water (Wilde, 1987). Chlorination is expected to be necessary to prevent biofouling of the proposed cooling tower systems for these reactors and dechlorination may be necessary to meet expected NPDES permit limitations on residual chlorine in the receiving streams.

Testing of chlorine demand and dissipation rates in April and May 1986 using K-Reactor cooling water effluent determined that a chlorine dose of approximately 3 mg/l is required to obtain a free residual chlorine (FRC) concentration of 1 mg/l in reactor cooling water (the FRC concentration typically required to prevent biofouling in cooling tower systems). The average total residual chlorine (TRC) concentration resulting from this chlorine dose was 1.7 mg/l.

Reduction of TRC to approximately background levels was usually achieved with a sodium sulfite dose of 1.5 times the calculated stoichiometric concentration. However, 2 times the stoichiometric amount of sodium sulfite produced slightly better dechlorination effectiveness. Therefore, based on the results of this study, with a chlorine dosage (ca. 3 mg/L) providing FRC and TRC concentrations of 1.0 and 1.7 mg/l, respectively, a sodium sulfite dose of approximately 6 mg/l would reduce TRC in the effluent to near background levels. BB-1 BC-16

Static 48-hour bioassays with bluegill collected from Par Pond showed no toxicity for cooling water containing up to 64 times the stoichiometric concentration of sodium sulfite calculated to remove residual chlorine.

In flow-through 96-hour bioassays with young-of-the-year largemouth bass and bluegill, no mortality occurred with chlorination at peak doses as high as 1.3 mg/L TRC at 20°C. At 30°C, LC 50 values for peak chlorine dosages ranged from 0.8 to 1.1 mg/l TRC. In the flow-through tests no mortality occurred with either species in chlorinated cooling water dechlorinated with 6 mg/l of sodium sulfite.

A sodium sulfite dose of as much as 25 mg/l resulted in no significant reduction in dissolved oxygen or change in pH with a contact time of 150 minutes. The concentration dosages required for substantial dissolved oxygen depletion were found to be more than an order of magnitude greater than the concentration (6 mg/l) proven to effectively dechlorinate SRP cooling water effluent chlorinated to an FRC concentration of 1 mg/l.

C.6 ENDANGERED AND THREATENED SPECIES

The Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.), is intended to prevent the further decline of endangered and threatened species and to bring about the restoration of these species and their habitat. The U.S. Fish and Wildlife Service (FWS) and the National Marine Fisheries Service

(NMFS) jointly administer this Act. The Act affords protection to some 300 species of native American plants and animals. A species can be listed Federally under either of two categories, "endangered" or "threatened," depending on its status and the degree of the threat. Endangered refers to a species or subspecies that is in danger of extinction throughout all or a significant portion of its range. Threatened means any species or subspecies that is likely to become endangered in the foreseeable future throughout all or a significant portion of its range. In addition, species may also be classified as "threatened due to similarity of appearance." This classification is afforded various species to ensure against excessive taking and to continue necessary protection to similar appearing species which are still classified as threatened. When a species is proposed for either the endangered or the threatened status, areas essential to its survival or conservation are proposed as "critical habitat," when appropriate. Compliance with the Endangered Species Act requires Federal agencies to consult with FWS and/or the NMFS regarding the implementation of a proposed action. If FWS or NMFS indicate that an endangered or threatened species (or one proposed as such) or critical habitat could be present in the area of the proposed action, a biological assessment must be prepared. This assessment is used as a basis for evaluating the effects on Federally protected species through the formal consultation process.

The State of South Carolina has a Nongame and Endangered Species Conservation Act (Section 50-15, 1976, S.C. Code of Laws). Rules established to implement the act protect Federally protected endangered and threatened wildlife that occur in South Carolina (R.123-150), sea turtles (R.123-150.1) and predatory birds of the orders Falconiformes and Strigiformes (R.123-160). The State does not afford protection to flora other than Federally protected species (DOE, 1982). Additions to the State protection listings can be made by the South Carolina Wildlife and Marine Resources Commission.

Table C-30 lists species of flora and fauna that have been documented at the Savannah River Plant (Dukes, 1984) and have been listed by the Federal Government (50 CFR 17.11 and 17.12, "Endangered and Threatened Wildlife and Plants") or State of South Carolina as endangered, threatened, or of special concern. The Savannah River Plant contains no areas that have been designated as critical habitat for any species.

TC

Formal consultations were held between DOE and the U.S. Fish and Wildlife Service to comply with the Endangered Species Act of 1973. Based on these consultations, the FWS issued a biological opinion that the preferred alternative cooling systems should have no effect on endangered and threatened species (Parker, 1986; Henry, 1986).

C.6.1 AMERICAN ALLIGATORS

TE

Sections 6.1 through 6.5 address the threatened and endangered species that occur on the Savannah River Plant. Much of the information presented in these sections is summarized from the Comprehensive Cooling Water Study (Du Pont, 1985). Additional information concerning other species listed in Table C-30 is in DOE, 1984.

Formerly high alligator population levels in the United States were greatly reduced by habitat alteration, indiscriminate killing, and legal, as well as illegal commercial harvest (Du Pont, 1985). By the 1950s, alligator populations were at an all-time low. Since that time, State and Federal law enforcement and management, as well as public education, have allowed the alligator to recover throughout much of its range. On June 4, 1987, FWS reclassified the American alligator from endangered to threatened due to similarity of appearance because the species is no longer biologically endangered or threatened throughout its range (FR 52 No. 107: 21059-21064). The threatened due to similarity of appearance status was retained to ensure against excessive taking and to continue necessary protection to the American crocodile, a morphologically similar species.

Alligators will feed on most aquatic and semiaquatic vertebrates and some terrestrial animals. Limited data suggest that fish make up the bulk of the alligator diet on the Savannah River Plant (Du Pont, 1985). American alligators have relatively broad temperature tolerances; the critical thermal maximum is estimated to be 38°C and animals have survived exposure to temperatures as low as 2°C to 4°C (Colbert, Cowles, and Bogert, 1946; Hagan, Smithson, and Doerr, 1983).

The American alligator occupies most major aquatic habitats at the Plant where water temperatures are suitable and food supplies are adequate (Du Pont, 1985). Large alligator populations occupy Par Pond and Beaver Dam Creek, areas that receive cooling water but have only moderately elevated temperatures. The Par Pond population has been studied most intensively; historically it has shown population parameters that indicated reduced reproduction in relation to more southerly populations. However, recent surveys indicated more extensive reproduction and a normalization of the age and sex structures (Du Pont, 1985). Recent surveys also indicate that Beaver Dam Creek might represent the most dense population of American alligators (Du Pont, 1985). At least 40 individuals were documented in less than 6 kilometers of the stream; clear evidence (i.e., two "pods" of hatchlings located 100 meters apart) indicated recent and successful reproduction (Du Pont, 1985).

Reproducing populations of alligators are known to occur in both post-thermal SRP stream systems, Steel Creek and Lower Three Runs Creek (Du Pont, 1985). A few alligators have been observed to move upstream in the reactor effluent streams when the reactors are not operating. Experimental studies confirm that alligators avoid lethal water temperatures associated with reactor start-up, even in winter when the animals' metabolic rates are low (Du Pont, 1985).

SRP operations have impacted the alligator population in many different ways. The creation of manmade reservoirs has dramatically increased the amount of aquatic habitat available to alligators. Therefore, it has increased the carrying capacity of the Plant for this species (Du Pont, 1985).

The thermal alteration of aquatic habitats has also impacted the resident alligator population (Du Pont, 1985). Temperature elevations greater than 38°C result in the loss of this habitat to alligators. Alligators respond to moderate thermal increases by moving to other locations. Observations suggest that alligators might utilize vertical and horizontal temperature profiles established by thermal loading to maintain their body temperatures at a preferred level; definitive data have not been collected (Murphy, 1981). Alligators around areas of thermal loading might also profit from extended breeding seasons or increased productivity by prey species. A serious negative influence of moderate levels of thermal loading appears to result from the induction of a premature reproductive season combined with differential use of thermal areas by adult male and female alligators (Murphy, 1981).

The current information available on the alligators of the Savannah River Plant suggests the following predicted trend: low density populations distant from thermally altered areas will continue at a low density with the exception of localized increases. The alligators inhabiting Par Pond should continue a trend toward a more normal size distribution and sex ratio as the reservoir matures and the older adults are replaced by the young (Du Pont, 1985).

C.6.2 WOOD STORKS

During the last 50 years the wood stork population declined from an estimated 20,000 breeding pairs in the early 1930s to approximately 4800 pairs in 1980 and 3650 pairs in 1983 (Ogden and Nesbitt, 1979; Odgen and Patty, 1981; DOI, 1983). FWS has listed the wood stork as an endangered species (DOI, 1984; 50 CFR 17.11 and 17.12).

The most northern and inland wood stork colony is located at Big Dukes Pond, a cypress swamp 12.6 kilometers northwest of Millen, Jenkins County, Georgia (Du Pont, 1985). This colony, referred to as the Birdsville colony, is the source of the birds foraging at SRP. The Plant is 45 kilometers from the Birdsville colony, a distance within the 60- to 70-kilometer radius that wood storks can travel during daily feeding flights (Du Pont, 1985).

The wood stork method of feeding is highly specialized. Wood storks wade in shallow pools, 15 to 30 centimeters deep, with their bills extended slightly forward and submerged as far as the external nares and opened about 8 centimeters at the tips. When a stork touches fish or other prey with its bill, the bird snaps the bill shut, capturing the prey. This method has been termed tactolocation. This feeding technique allows wood storks to forage in muddy or turbid water where birds that hunt visually cannot feed. To feed efficiently, storks forage in ponds where prey are concentrated. It is important that the birds feed in areas where prey are densely concentrated during the breeding season because food requirements are greatest when adults are caring for chicks (Kahl, 1964; Du Pont, 1985).

Wood storks are colonial nesters. They build large nests in trees, usually over standing water. Nest heights range from a few meters above water in mangrove swamps to the tops of the tallest cypress trees (Taxodium sp.) (Ogden and Nesbitt, 1979). Storks use cypress trees for nesting habitat most often; however, in southern Florida they use red mangrove, Rhizophoro mangle (Kahl, 1964).

Wood storks breed during the dry season when evaporation in shallow ponds concentrates the prey (Du Pont, 1985). Breeding lasts about 120 days, including time for courtship and nest-building. Two to five white eggs are incubated for 28 to 30 days. During the first 30 days after hatching, the young are attended by one parent while the other parent forages. During this period the chicks gain the ability to thermoregulate and grow to a size at which they are no longer vulnerable to their major predators, crows and vultures. As the food demand of the chicks exceeds the level that one parent can provide, the young are left alone at the nest while both parents forage. The young leave the rookery after about 65 days (Kahl, 1964).

Kahl (1964) estimated that during the breeding season the minimum fish biomass needed by a nesting pair of storks and an average of 2.25 fledge young was 201 kilograms. Feeding habitat, including cypress swamps and domes, scrub cypress, freshwater marshes, and mixed hardwood swamp, must be available within 60 to 70 kilometers of the stork colony. These habitats must also be productive enough to maintain fish populations at levels sufficient to allow an annual take by the colony equal to about 201 kilograms times the number of nesting pairs (Meyers, 1984).

Wood stork feeding sites for the Birdsville colony were studied during the second half of the nesting season in 1983 and for most of the 1984 and 1985 nesting season (Meyers, 1984; Coulter, 1986a,b). Feeding sites were located by following storks from the nesting colony and by surveying the SRP Savannah River swamp and other habitats near the colony. The following information was gathered from this research:

- Wood storks at Birdsville produced an average of 2.2 fledglings per active nest during 1983. About the same number of young were observed in 1984 (2.4 fledglings) and 1985 (2.5 fledglings). When the loss of entire nests is considered, the mean number of young per nest declined from 2.04 in 1984 to 0.33 in 1985.

- Wood storks forage up to 80 kilometers from the colony, but a majority (91 percent) of feeding flights during 1983 were less than 50 kilometers. During 1984, more than 80 percent of the foraging sites were within 20 kilometers and 55 percent were within 10 kilometers of the colony. During 1985, most sites (89 percent) were within 20 kilometers of the colony, and 46 percent were within 10 kilometers of the rookery.

- Of the 50 feeding sites located during 1983, 18 percent were located in SRP swamps (3 sites at the Steel Creek delta, 5 sites at Beaver Dam Creek, and 1 site near the Pen Branch delta) in 1983. Similar areas at SRP were used in 1984, along with additional foraging sites in the swamp between Pen Branch and Four Mile Creek. Two wood storks were observed feeding in Kathwood Lake on August 5, 1984; no other sitings were recorded during the surveys. In 1985, 58 percent of the feeding sites were in swamps and 23 percent were in Carolina bays and ponds. BB-3

- Before fledging (when young birds leave the nest) in 1984, 33 percent of the feeding sites were located at SRP. However, of the total number of adult storks observed feeding at that time, 64 percent were at SRP sites and 36 percent were not. During 1985, no wood storks were observed feeding at SRP prior to fledging.

- After fledging, juvenile wood storks did not feed at SRP sites in 1983.

- In 1983, storks fed in shallow pools with an average of 6.2 acres and depths between 10 and 32 centimeters. In 1984 and 1985, the median water depth was 22 and 21 centimeters, respectively. Habitat types for 1983-1985 included black gum swamp, cypress swamp, shrub swamp, open marsh, manmade ponds, and Carolina bays used as feeding sites.

BB-3 • Habitat use varied markedly from 1983 to 1985. The Steel Creek delta was heavily used in 1983 and 1984, but was infrequently used in 1985. Beaver Dam Creek was important to wood storks in 1983 and 1984, but none were observed there in 1985. The greatest use in 1985 was recorded on the Four Mile Creek delta and in the area between this delta and the Pen Branch delta.

• Direct and indirect effects from thermal effluent discharge from SRP facilities probably limit the potential use of the Savannah River swamp by foraging adult wood storks.

TE • If the Florida colonies continue to decline, the Birdsville colony will become relatively more important to the wood stork.

C.6.3 SHORTNOSE STURGEON

The shortnose sturgeon is listed by the National Marine Fisheries Service
TC (NMFS) as an endangered species in the United States (Du Pont, 1985; 50 CFR 17.11 and 17.12). This species is found only on the east coast of North America in tidal rivers and estuaries. Until recently, the presence of shortnose sturgeon had not been documented in the middle reaches of the Savannah
TC River. However, from 1982 to 1985, shortnose sturgeon larvae were collected near the Savannah River Plant as part of the SRP aquatic ecology program (see Section C.5.2.2; DOE, 1987). Because the shortnose sturgeon is anadromous, protection of this species is under jurisdiction of the NMFS. Critical habitat for this species has not been designated by the NMFS (Du Pont, 1985).

Breeding populations of shortnose sturgeon are normally associated with estuary-river complexes that have a strong flow of fresh water. The shortnose sturgeon's endangered species status has stimulated recent investigations that have shown it to be more abundant in some drainage systems than had been previously known (Brundage and Meadows, 1982).

Shortnose sturgeon have been found in rivers, estuaries, and the ocean with their greatest abundance occurring in the estuary of their respective rivers
TE (Dadswell et al., 1982). The few fish that have been captured at sea were found within a few miles of the mouth of an estuarine system. The species is primarily anadromous, but access to the sea is apparently not a requirement for reproductive success. Landlocked populations have been reported in the Holyoke Pool section of the Connecticut River (Taubert, 1980a,b) and the Lake Marion-Moultrie system in South Carolina (Marchette and Smiley, 1982).

Spawning of shortnose sturgeon occurs between February and May, depending on the latitude. The major factor governing spawning appears to be temperature, although other factors include the occurrence of freshets and substrate character (Dadswell et al., 1982). Several investigators have reported shortnose sturgeon spawning to occur between 9°C and 19°C (Heidt and Gilbert, 1978; Dadswell, 1979; Taubert, 1980a; Buckley and Kynard, 1981). Specific spawning grounds for populations in southeastern rivers have not been described. The shortnose sturgeon exhibits a migration pattern between spawning grounds, feeding grounds, and overwintering areas.

Although a segment of the Savannah River shortnose sturgeon population spawns upstream of SRP cooling water intake canals, entrainment of eggs is unlikely

(Du Pont, 1985). Sturgeon eggs are demersal and are usually deposited on rubble and gravel substrate (Buckley, 1982; Taubert, 1980b). Whether this substrate is utilized or available to the Savannah River population is not known. However, the negative buoyancy and strongly adhesive, gelatinous nature of the eggs preclude significant downstream transport or dispersion of eggs through the water column (Pottle and Dadswell, 1979).

Collections made near SRP indicate that some shortnose sturgeon larvae might be entrained (see Section C.5.2.2). However, it is not possible to accurately estimate entrainment losses due to the low number of specimens collected. Given the small number of shortnose sturgeon larvae collected and the relatively extensive ichthyoplankton sampling effort in the vicinity of the SRP site, the number of larvae entrained probably is small and their loss does not represent an adverse effect on the Savannah River shortnose sturgeon population (Du Pont, 1985). TC

In January 1983, one 147-millimeter juvenile Atlantic sturgeon was impinged on the intake screens (Du Pont, 1985). Thus, shortnose sturgeon might be impinged. However, there is no evidence that Atlantic or shortnose sturgeon commonly inhabit the intake canals. Shortnose sturgeon, unless injured, should be able to avoid the intake screens because their swim speed exceeds the pumphouse intake velocity (Du Pont, 1985).

Potential direct thermal effects on the shortnose sturgeon are limited to existing and any future thermal plumes in the Savannah River. Thermal plumes should not affect adults because they can avoid these areas; at present, a large zone of passage exists in the Savannah River for all migratory species (Du Pont, 1985). Eggs are not planktonic and should not drift through the plumes; however, newly hatched larvae could be swept into the plume under conditions of high water flow or drift downstream as part of a normal dispersion process. Although there are no temperature tolerance data on larval shortnose sturgeon, larvae drifting through the plume near the mouth of Four Mile Creek might not survive. This potential effect is expected to be limited because only adults spawning immediately above the thermal plume and larvae drifting through the hottest part of the thermal plume would be affected (Du Pont, 1985).

The NMFS had previously concurred in DOE's determination that the population of shortnose sturgeon in the Savannah River would not be adversely affected by SRP operations (Oravetz, 1983).

C.6.4 RED-COCKADED WOODPECKER

The red-cockaded woodpecker was once a common bird in the mature pine forests of the Southeast. Today its range and population have been reduced through loss of habitat. It is unique among North American woodpeckers in its selection of mature, living pines for cavity excavation (Jackson, 1978). The disappearance of mature pine forests (Whalenberg, 1946, 1960; Lennartz et al., 1983) has resulted in fragmentation of the required habitat. As a result, many red-cockaded woodpecker populations exist in isolated mature pine reserves (Jackson, 1977).

The red-cockaded woodpecker has a complex cooperative breeding system (Lennartz and Harlow, 1979). These birds live in groups called clans, are nonmigratory, and maintain large year-round territories (Ligon, 1970). The clan can consist of from two to nine birds, but there is never more than one breeding pair. The other adults are usually males called helpers. Some clans have no helpers, but others might have as many as three. The helpers assist in incubating eggs, making new cavities, feeding the young, and defending the clan's territory. A breeding male can live for several years. When he dies, one of the helpers usually inherits the status of breeding male (Lennartz and Harlow, 1979).

A clan nests and roosts in a group of cavity trees called a colony. Cavities are made in live pine trees. Each clan member tries to have a cavity for roosting. Birds without cavities in live trees often roost in forks between limbs or in cavities of dead trees. A cavity is seldom excavated in one year, and most take several years of work (Jackson, Lennartz, and Hooper, 1979).

The red-cockaded woodpecker nests between late April and July. Only the breeding male courts and mates with the female. The female usually lays two to four eggs in the breeding male's roost cavity. The breeding male stays with the eggs at night and the clan members take turns incubating during the day. The eggs hatch in 10 to 12 days. Young birds leave the nest in about 25 days (Ligon, 1970). The clan spends a great deal of time looking for food. Most of the foraging is concentrated on the trunks of live pine trees. The birds will scale the bark and dig into dead limbs for spiders, ants, cockroaches, centipedes, and the eggs and larvae of various insects.

The clan defends year-round a territory surrounding the colony. Territories range from less than 100 acres to more than 250 acres. The total area used by the clan can be as large as 1000 acres.

The Savannah River Forest Station's wildlife management program has concentrated on red-cockaded woodpecker habitat improvement since 1979. In July 1980, an intensive program was started to reduce encroaching hardwood understory in several colonies. The objective was to provide the open, park-like mature pine stands that are required. This type of habitat is scarce at SRP. About one-third of the forest area has been planted since 1951 and will require 30 or more years to provide suitable habitat. Much of the remaining area is either scrub oak or bottomland hardwoods.

The Forest Service is in the process of evaluating inventoried colonies of red-cockaded woodpeckers and their habitats and determining which habitats should be improved. No active colonies are located near the areas of proposed alternative cooling water system construction. In 1987, the Plant had three active breeding colonies, and the Southeastern Forest Experiment Station successfully cross-fostered two chicks from the Francis Marion National Forest to stabilize and increase the genetic diversity of the colonies.

C.6.5 BALD EAGLE

The federally endangered bald eagle is a fairly common permanent breeding resident in South Carolina and is most abundant in the coastal region (Sprunt and Chamberlain, 1970). The presence of this species on Par Pond was first recorded in May 1959 (Norris 1963), and has been frequently sighted since 1978 (Mayer et al., 1986). From September 1984 through August 1985, Mayer et al. (1986) reported 36 bald eagles, 92 percent of which were observed on the Par

Pond reservoir system; no active nests, however, were found. From September 1985 to January 1986, a total of 22 birds was observed, some of which were seen in the vicinity of the newly constructed L-Lake reservoir system. TC

Bald eagles migrate from southeastern to northern states and Canada in mid-summer; they return south in the fall and early winter to nest and rear their young (Sprunt and Chamberlain, 1970). TC

The first sighting of an active bald eagle nest occurred on June 5, 1986, below Par Pond dam in the Lower Three Runs Creek drainage area, and two eaglets fledged from the nest in 1987. Because this nest is outside the preferred alternative cooling impact zones and because of the implementation of management practices in accordance with the guidelines of the 1984 bald eagle recovery plan, the FWS issued a finding of no effect to this species in 1986 (Henry, 1986). TC

C.7 COMMERCIALLY AND RECREATIONALLY VALUABLE BIOTA

Commercially valuable plant biota on the Savannah River Plant include approximately 175,000 acres of timber that are managed by the Forest Service. The commercial value of SRP timber that was managed and sold by the Forest Service in 1982 was $1.7 million; this included pine and hardwood sawtimber, pine pulpwood, and cordwood hardwoods. Approximately 71 percent of the timber sales consisted of pine pulpwood. The longterm trend in planting activities has been an increase in the number of loblolly pine and a decrease in slash pine. The latter is more susceptible to injury from ice glazing and has not been planted since 1970. More than 1,530,000 loblolly pine seedlings and 160,000 longleaf pine seedlings were planted in 1980 (USDA, 1983). TE

Public hunts of deer and feral hogs, managed by the Forest Service, began in 1965. These hunts minimize deer-car accidents and maintain habitat quality. Since 1981, Du Pont personnel have planned and managed these hunts. TE

The annual number of hunter-days increased from 700 in 1966 to 6325 in 1980; paralleling this trend was an increase from 198 deer harvested in 1966 to 961 in 1980. The harvest of feral hogs ranged from 10 in 1972 to 32 in 1980. Additionally, there has been a relatively consistent decline in the number of deer-car accidents. In the late 1960s and early 1970s, there were more than 50 deer-car accidents; only 11 incidents were reported in 1980. TE

Other game species that have commercial and recreational value but have protection from hunting include the bobcat, fox, mink, muskrat, opossum, otter, rabbit, raccoon, skunk, squirrel, migratory waterfowl, bobwhite quail, mourning dove, wild turkey, Wilson's snipe, and woodcock. TE

The Savannah River supports both commercial and sports fisheries. Table C-31 lists the species and catches of fish taken commercially from the river from 1970 to 1979. Many of these fisheries are confined to the marine and brackish waters of the coastal regions of South Carolina and Georgia.

The only commercial fishes of significance near SRP are the American shad, the channel catfish, and the Atlantic sturgeon. These species, except for the sturgeon, are exploited to a limited degree by nonprofessional local fishermen. There is no fishery specifically for hickory shad in South Carolina or Georgia; however, many are taken each year incidental to the catch of American shad (Ulrich et al., 1978).

Sport fishermen are the principal consumers of river fishes, primarily sunfish and crappie. Striped bass, which is classified as a game fish in South Carolina and Georgia (Ulrich et al., 1978), is a favorite quarry of fishermen in the Augusta area.

Commercial and recreational fisheries for blueback herring exist in South Carolina (Ulrich et al., 1978), but none are taken commercially in Georgia because of state netting restrictions.

Although species of commercial or sport fishing importance in the Savannah River might use SRP streams, DOE does not allow fishing or other exploitation of commercial species.

The Fisheries Section of the Georgia Department of Natural Resources published the results of a creel survey in the estuarine and fresh-water sections of the Savannah River from December 29, 1979 to December 26, 1980 (Georgia Game and Fish Division, 1982). The most abundant species harvested in the fresh-water section were bluegills (29.1 percent), redbreast sunfish (27.5 percent), warmouth (10.6 percent), bullheads (7.1 percent), and crappie (6.2 percent). Those fish species comprising the greatest weight were bluegills (19.8 percent), redbreast sunfish (21.1 percent), warmouth (8.2 percent), largemouth bass (7.3 percent), and crappie (7.0 percent). Based on electrofishing studies conducted by the Georgia Game and Fish Division, the relative abundance of sunfish in the freshwater section of the river is high, as is the actual angler success rate. The success rate for largemouth bass (0.04 percent fish per hour) was low. The average-size striped bass (5.21 kilograms) creeled in fresh water was over four times greater than the average-size striped bass (1.19 kilograms) creeled in the estuary.

The most abundant species harvested in the estuarine section were croakers and spots (24.5 percent), white catfish (17.4 percent), silver perch (11.3 percent), and other species (26.3 percent). Species comprising the greatest weight were white catfish (23.9 percent), red drum (16.0 percent), and sea trout (12.9 percent). Angler success rates for all species were very low.

The greatest fishing effort in the estuary was expended for sea trout (42.1 percent), striped bass (29.9 percent), and red drum (17.3 percent). The five most sought-after species in fresh water were largemouth bass (38.0 percent), sunfish (30.5 percent), redbreast sunfish (12.7 percent), crappie (7.7 percent), and catfish (5.4 percent).

DOE (1987) cites evaluations made of the fishery resources in the Savannah River downstream of the New Savannah Bluff Lock and Dam during 1980-1982. Average annual sport fishing harvest from the freshwater portions of the river (approximately RM 21-187) was estimated to range from 171,561 fish/year in BB-3
1982 to 550,282 fish/year in 1980 (3 year averages = 305,778 fish/year). BD-5
Dominant species in the sport harvest were redbreast sunfish (27.2 percent) and bluegill (24.1 percent, Table C-28). The composite category of bream accounted for 64.0 percent of the total angler catch. The composite category

of catfish also represented a substantial portion of the sport harvest (14.6 percent), with bullhead spp. (8.2 percent) as the major reported taxon within this category. Crappie (8.0 percent) represented a substantial component of the sport harvest and was comparable to warmouth (7.3 percent). No other species (or species group) represented greater than five percent of the sport harvest. Notably, anadromous species (striped bass, 0.2 percent; American shad, 1.7 percent) did not contribute substantially to the angler's harvest. However, American shad harvest may be underestimated because of the development of a fishery for this species near the New Savannah Bluff Lock and Dam, while the assessment for this species emphasized downstream areas of the river.

The proportions of fish species caught by anglers were frequently in sharp contrast to angler preferences. Approximately 35 percent of angler fishing effort was directed toward bream (composite reporting category plus individual species), while 64 percent of the harvest was from this category (Table C-32). The relationship between effort and harvest was even more disparate for largemouth bass; 25.7 percent of the fishing effort was targeted toward this species, while it constituted only 3.2 percent of the catch. Overall, catfish were not highly desired (approximately 7 percent of effort), but were caught in slightly greater proportion (14.6 percent). American shad (7.8 percent of effort) and striped bass (4.7 percent of effort) were caught in substantially
BB-3 lower abundances than desired by sport fishermen, the disparity being
BD-5 comparable to that exhibited for largemouth bass.

Impingement relative abundances for all taxa of catfish [bullhead spp. (2.1 percent), channel catfish (0.8 percent) and white catfish (1.3 percent)] were lower than relative abundances for those taxa in the creel (8.2 percent, 4.2 percent, and 2.1 percent, respectively Figure C-9). However, the relative abundances of these taxa in hoop-net collections from the river were substantially higher than for either impingement or angler catches. The disparity between relative abundances of catfish taxa in electrofishing and hoop-net collections suggests that catfish are a substantial component of the Savannah River ichthyofauna, and that electrofishing provides poor estimates of the abundance of these taxa.

American shad, striped bass and hybrid bass were minor components in all the collection methods (angling, electrofishing, hoop-netting, impingement, Figure C-9). The abundance of the migratory American shad and striped bass in the Savannah River near SRP was undoubtedly underestimated during the quarterly sampling program. Nevertheless, the low frequency of these species in impingement collections (approximately 100 collections throughout the year) is highly encouraging because it indicates that adults and juveniles of these species are minimally influenced by impingement mortality associated with SRP operations.

C.8 HABITAT EVALUATION PROCEDURES ANALYSIS

The potential effects on wildlife of the implementation of thermal mitigation alternatives for C- and K-Reactors were evaluated using Habitat Evaluation
BD-4 Procedures (HEP) developed by the U.S. Fish and Wildlife Service (FWS) and modified by the Savannah River Laboratory for the Savannah River Plant (SRP) environment (Mackey et al., 1987). These procedures allow for the relative

Table C-32. Fishes Preferred and Caught by Savannah River Sport Fishermen[a]

Taxon	Percent Angler Effort	Percent Angler Catch
Bream	24.9	64.0[b]
Redbreast sunfish	8.7	27.2
Bluegill	1.0	24.1
Warmouth	0.1	7.3
Redear sunfish	0.4	4.4
Largemouth bass	25.7	3.2
Crappie	10.7	8.0
Yellow Perch	1.3	3.0
Catfish	7.0	14.6[b]
Bullhead spp.	0.4	8.2
Channel catfish	<0.1	4.2
White catfish	0.5	2.1
Chain pickerel	0.5	0.9
American shad	7.8	1.7
Striped bass	4.7	0.2
Hybrid bass	4.4	0.3
Other	1.9	4.1
Total	100.0	100.0

a. Source: DOE, 1987.
b. Sum of taxa within category.

BB-3
BD-5

ranking of project alternatives and/or mitigation with respect to representative wildlife species over the life of the project or for selected time periods in the future. The Department of Energy-Savannah River was requested by the FWS to provide an HEP analysis for the cooling water alternative for these reactors during the comment period on the Draft EIS.

For C- and K-Reactors the potential wildlife impacts and/or benefits of once-through and recirculating cooling towers were evaluated for both near-term (30-year) and long-term (100-year) time periods. These options were evaluated against the projected effects of the current operations, i.e., release of once-through cooling water effluent directly to Four Mile Creek and Pen Branch from C- and K-Reactors, respectively. Those species that were selected as representative of potential project effects in terrestrial environments included the pine warbler, downy woodpecker, cottontail rabbit, gray squirrel, white-tailed deer, and eastern wild turkey. Those species selected to represent aquatic and/or semi-aquatic environments included the creek chub, redbreast sunfish, black bullhead catfish, blueback herring, great egret, wood duck, mallard, and yellow-bellied slider. The land cover data base for the habitat cover maps for the HEP assessment was developed using Geographic Information System (GIS) methods and remote sensing aerial photography and multispectral scanner data. Much of the data to predict future changes in Four Mile Creek, Pen Branch, and the SRP Savannah River swamp was BD-6 developed from previous remote sensing studies and from the Comprehensive Cooling Water Study (CCWS) and L-Reactor restart studies.

BD-4 For the various cooling water alternatives, the following relative rankings of future wildlife effects were determined. Effects on terrestrial wildlife from construction of the once-through and recirculation cooling towers are essentially equal since in both cases either type of tower would be constructed at the same location and pipeline and other support facilities would affect essentially the same locations. Small stream species, such as the creek chub, benefit more from the recirculation alternative in the upper reaches of the creeks. In the middle and lower reaches, species such as the catfish and sunfish benefit more from the once-through alternative. In the deep swamp environment, those fish which are more likely to use the swamp during the spawning period benefit more from the recirculation alternative. In the Savannah River swamp, wading birds such as the great egret benefit more from the recirculation alternative. Overwintering waterfowl such as the mallard benefit more either from the present SRP operations or from the once-through cooling tower. These alternatives either maintain the existing "marsh" type environment in the swamp for wintering waterfowl or permit expansion of this type of habitat as deep swamp wetlands (cypress/tupelo) are reduced and converted to more open wetlands by the future release of high flows of cooling water effluent. Similar trends were noted for both C- and K-Reactors for both the short-term 30-year and long-term 100-year analyses.

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